



◆ Objectives - Space Transportation Research Investment Area

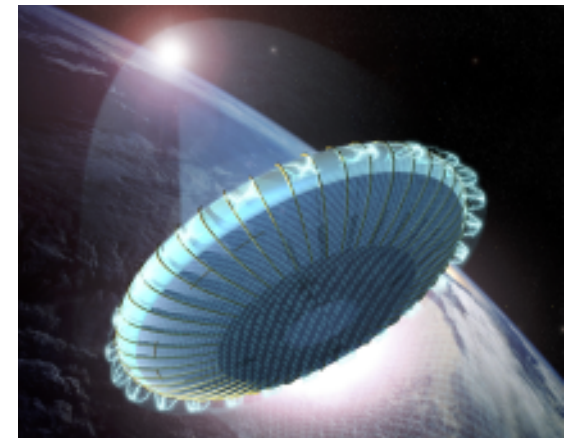
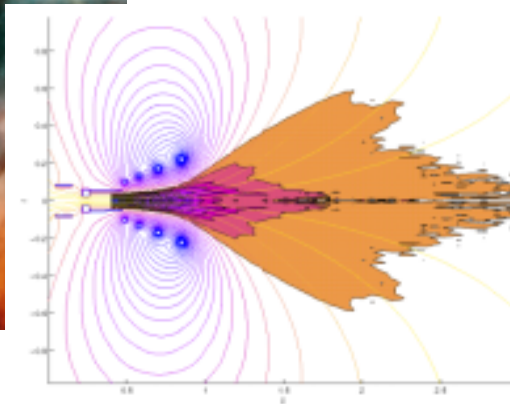
- Responsible for developing the technologies to enable bold new missions.
- Research will pursue proof-of-concept in revolutionary technology areas that may lead to
 - Dramatic reductions in the cost of access to space
 - Enable new interplanetary or interstellar space missions by reducing travel times by one to two orders of magnitude.
- This investment area involves
 - Breakthrough Propulsion Physics Project
 - Advanced Propulsion Research Project

◆ Areas of Propulsion

- Advanced Chemical
- Electromagnetic
- Advanced Nuclear
- Fusion / Antimatter
- Interstellar Research
- Breakthrough Propulsion Physics

Project Health Indicators

| Cost | Schedule | Issues |
|------|----------|--------|
| G | G | G |





Breakthrough Propulsion Physics

2000 PMC —

BPP PROJECT

OBJECTIVE

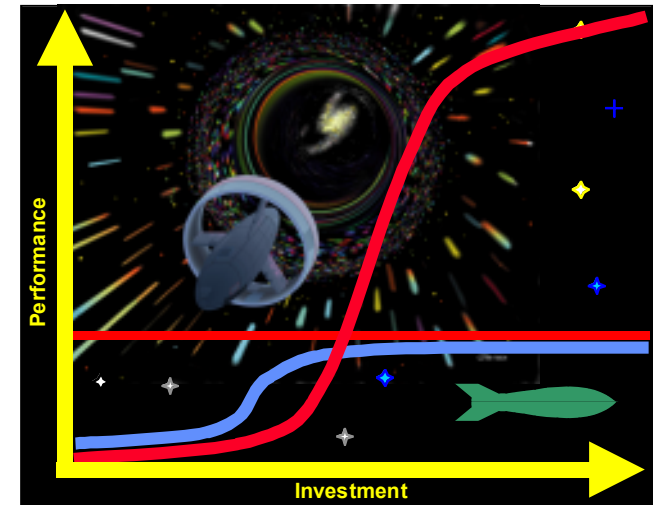
Produce near-term, credible, and measurable progress toward conquering the ultimate breakthroughs needed to revolutionize space travel and enable interstellar voyages...

BREAKTHROUGHS SOUGHT

1. **MASS:** Discover new propulsion methods that eliminate or dramatically reduce the need for propellant.
2. **SPEED:** Discover how to attain the ultimate transit speeds to dramatically reduce travel times (includes faster-than-light *if* it can be credibly shown to be physically possible).
3. **ENERGY:** Discover fundamentally new modes of on-board energy generation to power these propulsion devices (energy physics linked to propulsion physics).

APPROACH

- Advance *science* to seek new propulsion methods to surpass the *limits* of *existing technology*.
- Focus on the next make-or-break issues using short-term, incremental research.
- Explore multiple, divergent approaches simultaneously.
- Combine vision with credibility.



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STRATEGY AND PROGRESS

- (1) **1996** - Determine if sufficient scientific foundations exist (yes). (NASA TM-107381)
- (2) **Continuing** - Network to identify possibilities and foster collaborations.
 - BPP Project Web Site <http://www.grc.nasa.gov/WWW/bpp/>
 - Conference Sessions, Workshops, Publications (\approx 65 publications)
 - Coordination with other advanced technology projects (Interstellar, NIAC, et. al).
- (3) **1997** - Determine if affordable candidate research tasks exist (80 ideas). (CP-1999-208694)
- (4) **1999** - Solicit , select, and support 1st round of research tasks (5 tasks). (NRA-99-LeRC-1)
- (5) **2000** - Determine next project strategy based on quantity of quality proposals ($^{13}/_{60}$).
- (6) \geq **2001** - Assess progress (via workshop format, T.B.D.).

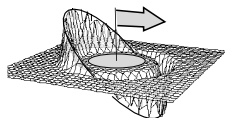
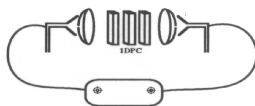
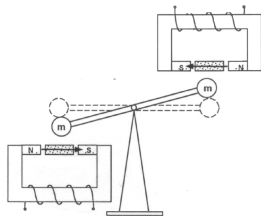
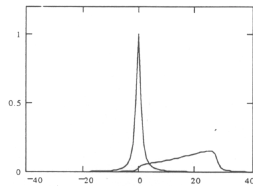
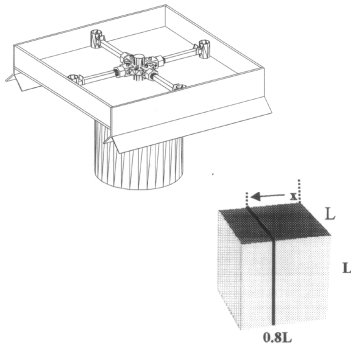
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Breakthrough Propulsion Physics

2000 PMC

BPP NRA Selections ($\Sigma = \$467K$, Code-S & Code-R FY99+FY00)



1. Independent test of Woodward's transient inertia effect.

If genuine, effect may enable thrusting directly against space itself. -- U of Washington, Seattle, **PI:** Dr. J. Cramer.
\$69K 1yr, Final report due February 2001.

2. Experimental (MEMS) and theoretical (QED) investigation of quantum vacuum energy.

Addresses make/break issues: energy existence, magnitude, and transferability. -- Quantum Fields, WI, and MEMS Optical, Huntsville, AL, **PI:** Dr. Jordan Maclay.
\$171K 3yr, NAS3-00093, Final report due Dec 2002.

3. Experimental test of electrodynamic torsion tensor theory.

If genuine, theory provides more flexibility to investigate applications of the coupling between mass, charge, and spacetime. -- Washington Univ, St. Louis, MO, **PI:** Dr. Harry Ringermacher of GE Corp. R&D.
\$100K 1yr, NAS3-00094, Final report due January 2001.

4. Experimental exploration of anomalous gravity effect using superconductors.

If genuine, effect provides a tangible means to affect gravitational or inertial forces. -- MSFC, **PI:** Tony Robertson.
\$37K 1yr, Final report due 2001.

5. Experimental and theoretical tests of superluminal hypothesis with quantum tunneling.

Addresses make/break issues of the light-speed limit. Univ NM, Albuquerque, -- **PI:** Dr. Kevin Malloy.
\$90K 1yr (+\$80K 2nd yr, FY01), NAS-300103, Final report due Feb. 2002.

6. Theoretical assessment of negative energy requirements for hyperfast travel.

PI: Dr. Serguei Krasnikov. --Not fundable since PI returned to Russia--
USAF EOARD may support (was **\$12K 1yr**)

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NOTE: Summaries of the selections are available at:
http://www.grc.nasa.gov/WWW/PAO/pressrel/99_66a.htm



◆ Activities Underway

- Advanced Hydrocarbon fuels testing, with AFRL-Edwards
- Solid hydrogen for atomic recombination energy fuel testing, at GRC.
- Pulse Detonation Engine (PDE) code development with UTSI
- Pulse Detonation Rocket Engine (PDRE) low cost construction and tests, in-house at MSFC
- Deeply Cooled Air Rocket / Turbojet Proposal with MSE for Air Force (AFRL-E) SBIR
- Air Augmented Aerospike CFD analysis task in-house at MSFC
- Gun Launch to Space atmospheric steering task in-house at MSFC

◆ Status of Advanced Hydrocarbon Fuels Testing

- Rig cleaning and assembly completed
- Initial fuels testing initiated
- Precipitate from bicyclopropyldene (unexpected) under study.

◆ No Cost or Schedule issues.

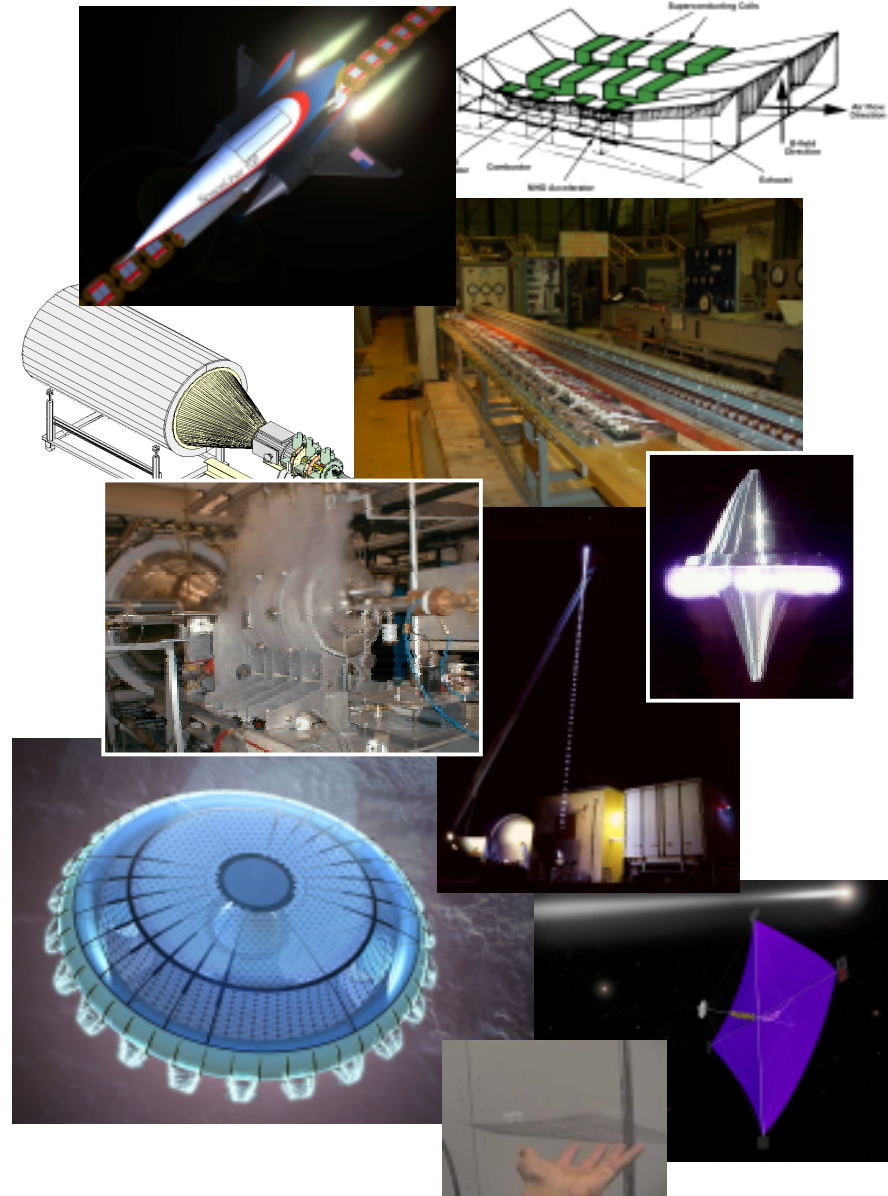




◆ Activities Underway

- Megawatt class power electric thruster testing preparations proceeding at JPL
- Plasma rocket (VASMIR) experiments proceeding at JSC
- Laser Propulsion, with RPI, AFRL-E, ARMY & MSFC at White Sands, New Mexico
- Laser propulsion CFD code development , in-house at MSFC
- On-Board Laser Ablative propulsion assessment for in-space propulsion, by JPL
- Microwave Propulsion, with RPI, MSFC
- Magnetic launch assist stability experiments , Foster Miller track in-house at MSFC
- Analysis of AJAX type scramjet vehicle system, underway at ARC
- Russian AJAX engine simulator acquisition proposal via Air Force SBIR , with ARC and Lytec. (SBIR Approved)
- Weakly ionized gas drag reduction and flow control, at MSFC with Accurate Automation Inc.

◆ No cost or schedule issues.

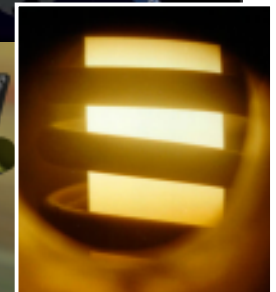
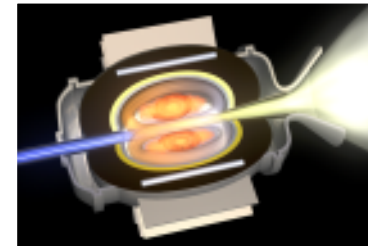
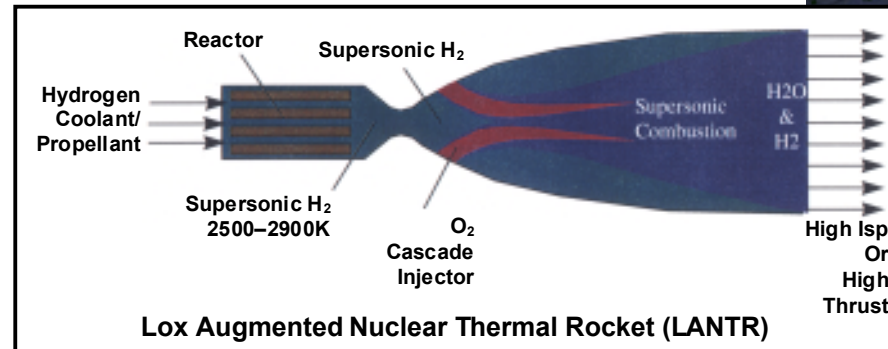




◆ Activities Underway

- LOX Augmented Nuclear Thermal Rocket hot fire preparations, at GRC
- High temperature nuclear fuels characterization, at Univ. Florida
- Down Hole test concept analysis, by Los Alamos and Bechtel Nevada, Inc.
- Concept analyses for ORION and ABCC (Atomic Base Combine Cycle), in-house at MSFC with Sandia and UAH
- Simulated testing of a small nuclear propulsion system, In-house at MSFC with Los Alamos
- Analysis of nuclear propulsion demonstrator concepts, in-house at MSFC with Los Alamos

◆ No Cost or Schedule Issues



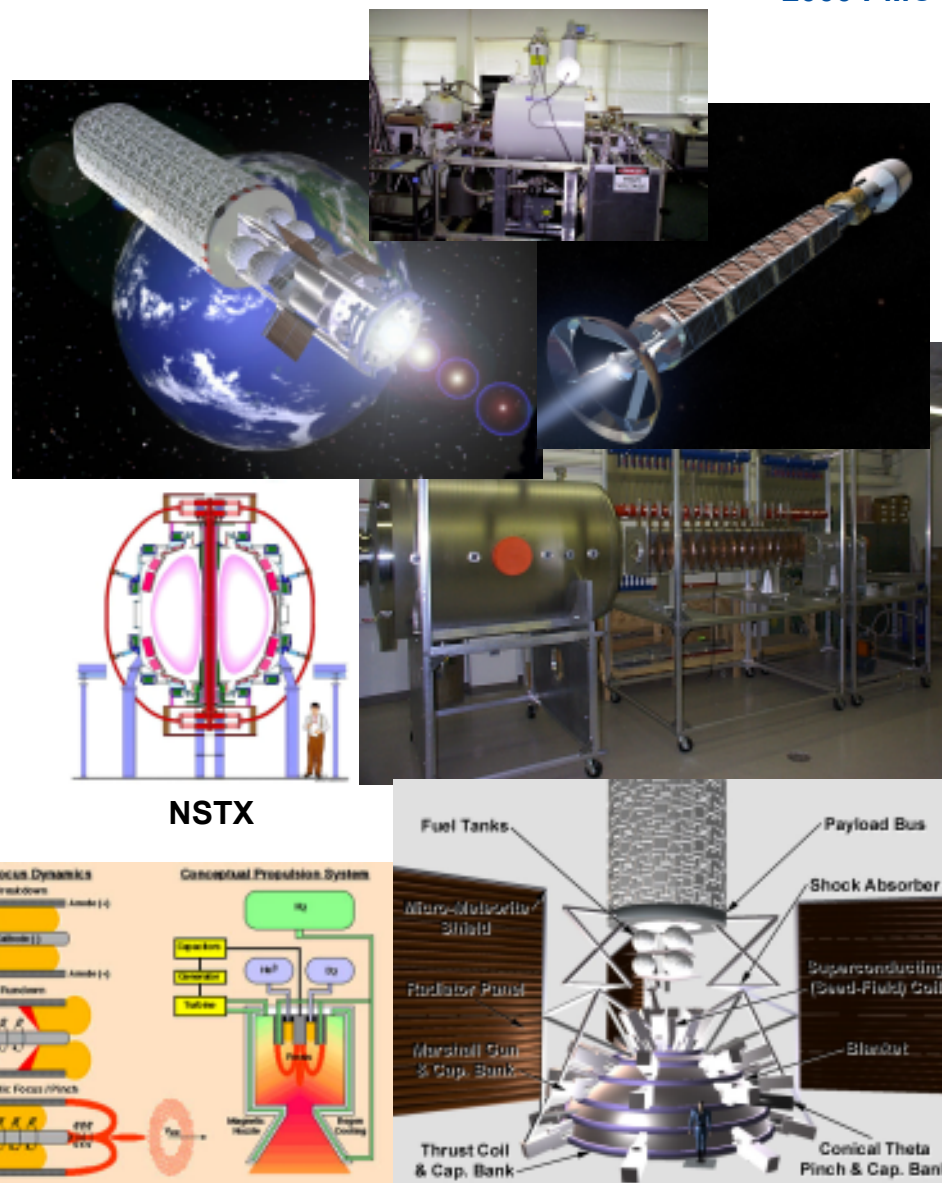
Processing of a Nuclear Fuel Sample



◆ Activities Underway

- Fusion Propulsion Planning Team, led by MSFC but involving many DOE labs and Univs.
- Magnetic Nozzle design methodology and concept test, by GRC with Ohio State
- Coaxial Helicity Ejection using NSTX, by GRC and Princeton
- Gas Dynamic Mirror fusion-like plasma generator and control, at MSFC with Univ. Mich.
- Magnetized Target Fusion concept analysis, in-house at MSFC with Los Alamos
- Anti-proton traps, at MSFC and JPL with Penn. State
- Dense Plasma Focus, by JPL and Univ. Texas
- Z-Pinch plasma stabilization, by Univ. Nevada at Reno

◆ No Cost or Schedule Issues





◆ Activities Underway (MSFC and JPL)

- Beamed Energy Laser Sail Technology
- Microwave Sail Technology
- Antimatter Propulsion
- Advanced Carbon Fiber Sails
- Novel Sail Configurations
- Field Emitter Arrays
- Nuclear Electric Propulsion
- Pulsed Plasma Propulsion
- Advanced Concepts

◆ No Cost or Schedule Issues

